



# GOOD TIMING

## Implementing STEM careers strategy in secondary schools

Final report of the STEM Careers Awareness Timeline Pilot  
November 2011

*Good Timing* is the final report of a three-year programme of work, commissioned by the Department for Education, and carried out by the Centre for Education and Industry at the University of Warwick (CEI), the International Centre for Guidance Studies at the University of Derby (iCeGS) and Isinglass Consultancy Ltd. The programme sought to explore the potential to embed STEM careers awareness in the early stages of secondary education.

The programme comprised:

**A pilot in all English regions, exploring how schools could embed awareness of STEM careers into the curriculum at Key Stage 3.**

Mentors from CEI and iCeGS audited existing practice, shared ideas and information, and supported planning for STEM in 27 pilot schools.

**Research into the attitudes and ambitions of Key Stage 3 pupils in pilot schools, in relation to STEM careers.**

Survey-based work was carried out by iCeGS at the University of Derby, in autumn 2008 and 2010, reflecting pupils attitudes and ambitions, at the start and end of the key stage. Over 4000 pupils took part in the phase 1 survey, and over 2000 in phase 2. Research findings can be found in two reports:

- STEM Careers Awareness Timelines: Attitudes and ambitions towards science, technology, engineering and mathematics (STEM at Key Stage 3). Hutchinson J, Stagg P, Bentley K. 2009. Derby: International Centre for Guidance Studies (iCeGS), University of Derby  
[www.derby.ac.uk/files/icegs\\_stem\\_careers\\_awareness\\_timelines.pdf](http://www.derby.ac.uk/files/icegs_stem_careers_awareness_timelines.pdf)
- STEM Careers Awareness Timelines: STEM subjects and jobs: A longitudinal perspective of attitudes among Key Stage 3 students, 2008–2010. 2011 Hutchinson J, Bentley K.  
[www.derby.ac.uk/files/icegs\\_stem\\_subjects\\_and\\_jobs\\_march2011.pdf](http://www.derby.ac.uk/files/icegs_stem_subjects_and_jobs_march2011.pdf)

**Consultation with pilot schools and key stakeholders.**

Five regional stakeholder conferences and two workshops were held to inform the project's strategic development and informing the development of the planning tools. A summary of the conferences can be found in the interim report:

- Lengthening Ladders, Shortening Snakes: Embedding STEM careers awareness in secondary schools Finegold P. 2009. Warwick: Centre for Education and Industry (CEI), University of Warwick  
[www2.warwick.ac.uk/fac/soc/cei/news/approvedpdfsnakes\\_laddersreport\\_v6\\_lr1.pdf](http://www2.warwick.ac.uk/fac/soc/cei/news/approvedpdfsnakes_laddersreport_v6_lr1.pdf)

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## Foreword



The UK is a premier scientific and technological nation. With 1 percent of the world's population, we produce 14 percent of its top-rated scientific research, and STEM skills are fundamental to the UK economy. Yet the CBI reports that 40 percent of employers have difficulty recruiting enough people with the STEM skills they need – and this demand is found right across the economy, not just in the scientific and high-tech sectors. And the demand is not only for graduates, but for STEM skills in technicians and apprentices too.

STEM qualifications open the door to a rich choice of fulfilling and well-paid careers, but not all young people realise this. Often, it is students from less privileged backgrounds who have most to gain by choosing to study STEM, yet it is often they who are least aware of the opportunities this brings.

Schools and colleges owe it to their students to provide impartial advice on the careers open to them, and in particular on the fact that, although they may not seem the easiest choices, science and mathematics offer the widest range of future careers. Providing this advice cannot be achieved by the careers advisory profession alone, and there are many ways that schools and colleges can open students' eyes to the world of STEM, through visits, field trips and by bringing students into contact with young role models who have successfully made STEM choices. Above all, teachers of STEM subjects can show, in the course of their lessons, how science, technology and mathematics in the curriculum link to the world outside and to the work that scientists and engineers do in their everyday lives.

This report describes some of the many ways that schools and colleges can adopt a strategic and structured approach to show their students the rich career potential of STEM, and it will provide a valuable source of inspiration on what can be achieved.

A handwritten signature in black ink, reading 'John Holman'.

Sir John Holman is Professor in the Chemistry Department at the University of York, Senior Fellow for Education at the Wellcome Trust and former National STEM Director.





# Executive summary

In recent years the UK has seen an unprecedented rise in the interest of Government, industry and others in the uptake of STEM subjects in schools and colleges. This has been driven by the need to ensure that young people gain the skills and aspirations essential for building the UK's economy and to help them participate in an increasingly scientific and technological society.

Reflecting the importance of STEM, a programme of activity was established in England to drive sustained change in how schools addressed the links between science, technology, engineering and mathematics.

Within this programme, the STEM Careers Awareness Timeline Project was commissioned to explore the potential to embed careers activity in STEM subject lessons and extracurricular programmes for pupils at Key Stage 3. A programme of research, consultation and mentoring with 27 secondary schools in all English regions, was used to develop a series of models and resources to enable other schools and colleges to embed a STEM careers ethos and develop a strategic approach to STEM careers information.

The Timeline Project identified several factors associated with a successful STEM careers school. Senior leaders will be committed to STEM and a STEM coordinator will have been appointed, with an appropriate level of authority to take this work forward. Teachers in all STEM subjects will be sufficiently well-trained and confident to present STEM careers activity within their teaching and in schemes of work. The general careers provision in the school will also be of high status, led by a capable careers coordinator who is seen as a valued partner by the school STEM community.

Recent changes in policy may make it harder to achieve successful STEM careers provision, since budget-conscious school managers may choose to scale back their commitment to careers to the minimum statutory requirement. This may mean simply directing pupils to online resources, without the mediation of skilled careers information, advice and guidance professionals. The introduction of progression measures, identifying the proportion of school leavers from a given institution who achieve a 'positive outcome' may act as an incentive for schools to focus on employability skills and transition planning.

Design and technology, and science were popular subjects among Key Stage 3 pupils surveyed. There was no evidence for a fall in popularity of science at this key stage, though there was a marked reduction of 12 percent over the two years, in the numbers of pupils stating that they 'enjoyed' mathematics. Engineering was seldom taught as a subject or identified in other STEM subjects as a specific discipline. Engineering and technology were perceived to be less important by pupils as they progressed through Key Stage 3, whereas the value of science and mathematics increased.

Pupils at this age were most likely to seek information about careers from their subject teachers and families, though half of year 9 pupils considered the internet, though not social networking, to be a good source of information on qualifications and work.

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STEM enrichment and enhancement activities tended not to focus on careers. Much of this activity took place through extracurricular clubs and school trips, most of which had a science theme. School visits based around mathematics, technology and engineering were less common.

Two strategic planning tools, the STEM Manager and STEM Planner, have been developed to help schools to establish an environment in which STEM careers can flourish, and to support schools in producing a timeline of enhancement activity, balanced across STEM subjects and through Key Stage 3. These online tools are available on the National STEM Centre's eLibrary.

# Key findings

- STEM activity in schools is complex, in that it cuts across well-embedded traditional subject departmental structures.
- Most secondary schools do not have a clear strategy for teaching and learning about engineering, and lack the staff with appropriate expertise in this area. The exceptions are schools and academies with an engineering specialism. Where it does occur, learning about engineering is normally restricted to extracurricular activity, reaching only small groups of enthusiasts.
- Successful STEM activity in schools, including STEM careers, is reliant on senior leadership support, which includes committing adequate resources and establishing a STEM coordinator role, with appropriate status.
- Better STEM careers activity arises where subject teachers see the preparation of young people for work, as an integral part of their professional role, and where they have the professional skills and confidence to act on this.
- Careers education does not normally have high status in schools and the relationship between careers provision and individual subject departments is often weak or non-existent.
- Schools that have set up STEM working groups involving careers staff, STEM teachers and senior leaders are able to offer a better STEM learning experience for pupils.
- There is a risk that STEM careers support in schools may be scaled down as a consequence of the Government's Education Bill in which schools will have a statutory duty to ensure that pupils are provided with careers guidance, and which gives schools flexibility over how it is provided.
- Teachers often see science as the driver for STEM. This may reflect the status that science and mathematics have as compulsory subjects, as well as science teachers' greater ability to reach out beyond their subjects.
- Attitudes of parents to STEM are a key factor influencing young people's future qualification and career choices. Cultural factors, parental aspiration and familiarity with STEM subjects, are thought to influence these attitudes.
- Families, peers and subject teachers are the most usual sources of careers information for this age group.
- Some of the most effective STEM activity occurs in more informal learning contexts, though the provision is not uniform across STEM subjects, with significantly more school trips and clubs being science focused. Non-white British pupils are more likely than other groups to participate in informal STEM learning experiences
- STEM enhancement and enrichment activities are often seen as a mechanism for generating interest in the subjects, but tend not to be valued for careers learning potential.



# Recommendations

1

The momentum generated in embedding STEM in schools should be maintained. The current economic backdrop means that, more than ever, schools with a robust STEM approach will offer their pupils better future career opportunities.

2

School senior leaders should offer fully committed and long-term support to STEM careers. This might include: (i) appointing a STEM coordinator with appropriate status; (ii) providing adequate resource to promote strategic planning across all STEM departments; and (iii) strengthening the contribution of careers specialists in curriculum planning.

3

STEM subject teachers should have professional development that builds their knowledge and understanding of careers and the labour market, so that they are better able to support pupils' career-related learning.

4

School leaders should carefully consider the impact of scaling down careers support in school, in light of the Education Bill. The temptation to interpret the statutory requirements at a minimum level will be detrimental to pupils' futures.

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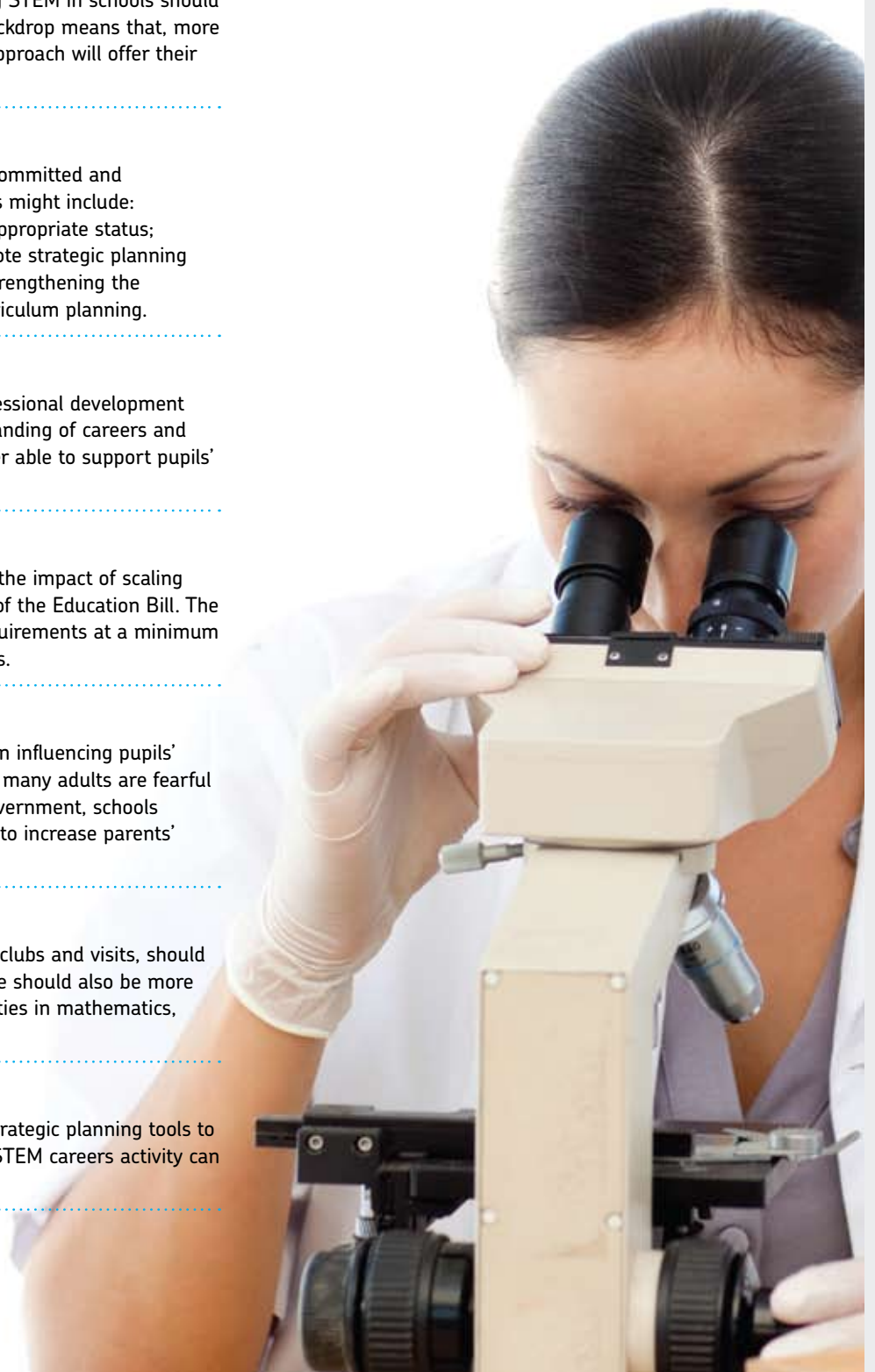
The importance of parents and families in influencing pupils' career choices is often overlooked. Since many adults are fearful or simply unaware of STEM subjects, Government, schools and other agencies should consider how to increase parents' awareness and confidence.

6

Informal STEM learning activity, such as clubs and visits, should be more explicitly linked to careers. There should also be more enrichment and enhancement opportunities in mathematics, design and technology, and engineering.

7

Schools should make use of the STEM strategic planning tools to help establish an environment in which STEM careers activity can take root and flourish.





# Constructing a timeline

## Weaving STEM careers into the curricular fabric of secondary schools

In recent years the UK has seen an unprecedented rise in the interest of Government, industry and others in the uptake of STEM subjects in schools and colleges. This has been driven by the need to ensure that young people gain the skills and aspirations that will contribute to building the UK's economy and to help them participate in an increasingly scientific and technological society.

Reflecting the national importance of increasing interest in STEM, in 2008 the previous Government commissioned a programme of activity in England to drive sustained change in how schools addressed the links between science, technology, engineering and mathematics. Former National STEM Director, Professor Sir John Holman, oversaw the establishment of 11 Action Programmes that collectively sought to integrate STEM into school and further education.

The National STEM Programme was designed to support this ambition in four strategic areas:

- Getting the right teachers
- Providing high-quality continuing professional development throughout teachers' careers
- Enhancing and enriching the STEM curriculum
- Communicating the diversity and value of STEM career opportunities

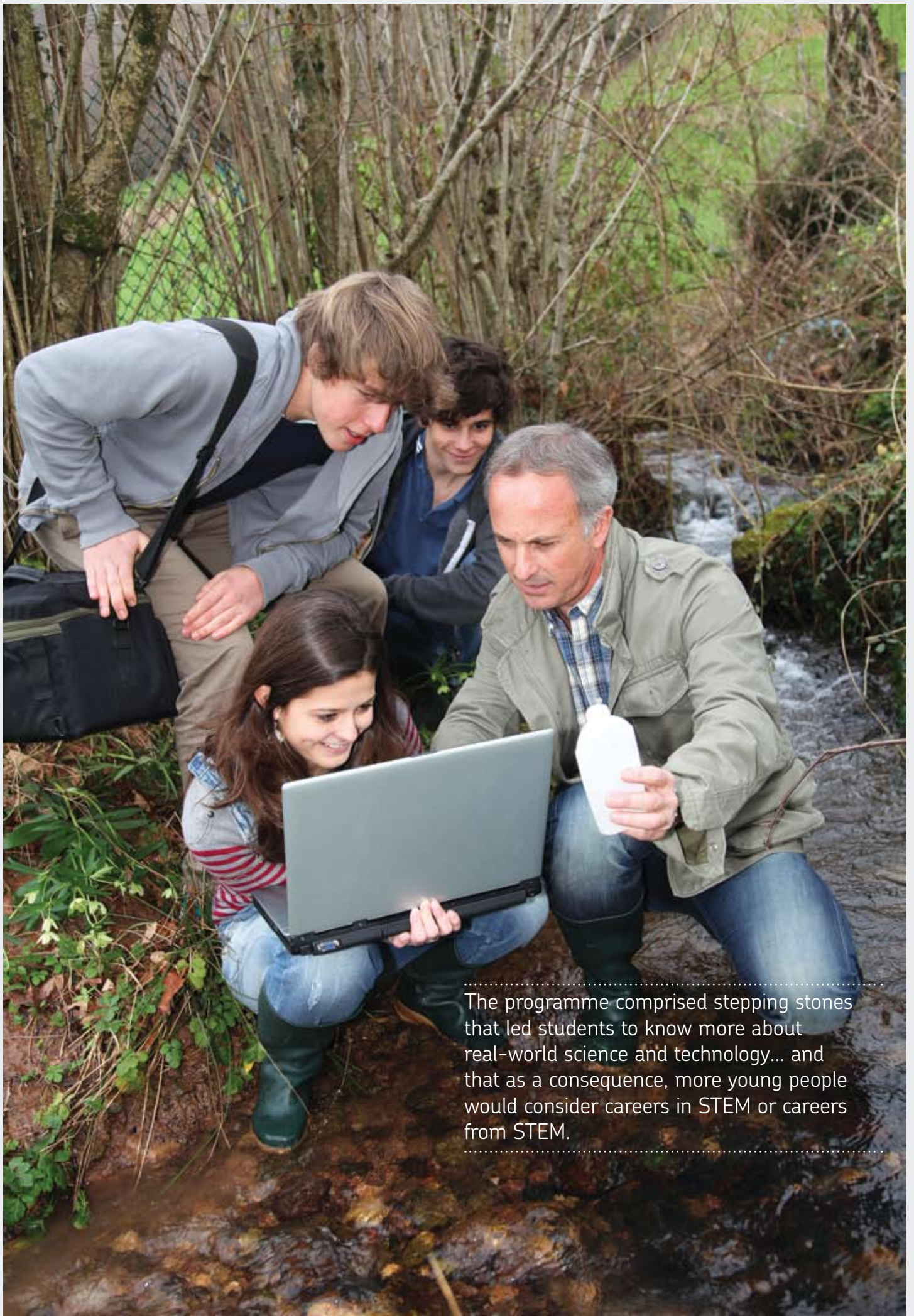
The action programme comprised stepping stones that led students to know more about real-world science and technology. The rationale was that, as a consequence, more young people would consider careers in STEM, or careers from STEM. At the very least, the dedicated careers programmes were able to challenge negative views about the limited qualifications and work opportunities offered through STEM, with its mantra: "Science and Maths. See where they can take you."

The STEM Careers Awareness Timeline Project, was one of four strands responsible for delivery of Action Programme 8, seeking: "To improve the quality of advice and guidance for students (and their teachers and parents), and to inform subject choice."

The STEM Careers programme developed approaches that provided the knowledge and skills so that schools would be better able to support young people in making informed subject choices about future careers, and to encourage them to keep their options open.

The Timeline team, comprising the Centre for Education and Industry (CEI) at the University of Warwick, the International Centre for Guidance Studies (iCeGS) at the University of Derby, and Isinglass Consultancy Ltd, was tasked with mentoring a range of secondary schools to see which approaches worked for them in embedding STEM careers awareness more deeply in day-to-day activity across Key Stage 3. The partners employed a combination of research, mentoring and stakeholder consultation to establish a clear set of guidelines about what schools can do to establish a lasting 'STEM ethos', and to improve the careers awareness of young people, particularly about those careers that use STEM skills.





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# STEM careers and the culture of schools

At the heart of the Timeline project, lay the participating schools. Some 27 schools across all English regions were asked to engage, either because they had shown an enhanced interest in STEM enrichment and enhancement, or in career-related learning. The project sought to establish the potential for careers learning to take place within the Key Stage 3 curriculum, including enhancement and enrichment activity, and to explore what could be done to create better links between STEM subject content and careers awareness.

Each school was asked to nominate a contact, who in most cases, became the STEM Timeline project lead, and was responsible for liaising with one of a cohort of experienced mentors. Each mentor helped a number of pilot schools to audit their existing STEM activity and develop a coherent set of STEM careers awareness activities throughout Key Stage 3. Through these relationships, mentors were also able to gain insight into the organisational and cultural factors that characterised successful interventions and to identify factors that acted as obstacles to STEM careers. This intelligence has proved invaluable in informing how STEM careers awareness may become better integrated within schools, and has led to the development of strategic online planning tools available on the National STEM Centre website.

## What are the characteristics of a successful STEM Careers Timeline school?

In a successful Timeline school, careers activity is embedded in schemes of work. STEM teachers are aware of overlap between subjects through the key stage and refer to 'real-world' relevance of concepts and ideas as a matter of course. STEM teachers and careers staff (external and internal) provide a balanced mix of STEM-related career and qualification options, generic careers-related information and impartial careers guidance. STEM departments plan strategically for the key stage so that careers references permeate curricular and extracurricular activity. All pupils begin to explore the range of potential career paths they could follow, aspire to new ambitions and are aware of a range of sources of information and advice. The school will also recognise the close links between STEM, employability skills and enterprise.

## Senior leadership, coordination and careers

In recent years schools have experienced a prolonged period of change, during which teachers have been subject to numerous government initiated programmes. Partly for this reason, the mentoring team observed that commitment to STEM from senior managers was vital in communicating its status among staff. Enthusiasm among the senior leadership team for the Timeline work, established the right ethos, which in turn generated the level of support necessary for coordination across subject departments. Success was more likely where a member of staff was assigned the role of STEM coordinator, and had a clearly defined role, articulated in a job description, and where STEM careers activity was adequately resourced.

Schools were most effective at communicating messages about STEM careers when they had policies in place that aligned with the school development plan.

Careers education generally does not have high status in schools, and the relationship between the careers coordinator and heads of subjects is often weak. Unsurprisingly, where careers education had low visibility, it was difficult to raise awareness about STEM careers at Key Stage 3. Some attempts are now being made by Government to improve the professional status of those working in careers information, advice and guidance, but the comparatively lowly status of many careers professionals in schools has made it hard for them to contribute to strategic decision-making. Schools that have set up STEM working groups, which include heads of STEM subjects, careers and enterprise staff, have had greater success.

Subject teachers often saw themselves as having little or no role to play in developing career competencies, believing 'careers' to be focused on occupational information and GCSE choices, and not about the development of generic skills and attitudes necessary for career exploration, decision-making and career management. Many identified strongly with their own specific subject, limiting the breadth of career references, especially in connection to engineering. These attitudes were seen as hard to shift and a major impediment to embedding careers within and across STEM subjects. Inclusion of careers-related activity in individual STEM teachers' professional development plans could help to challenge some of these entrenched views.

The Education Bill replaces the requirement to provide careers education from year 9 with the enactment of a new statutory duty for schools to:

“Secure that all registered pupils at the school are provided with independent careers guidance during the relevant phase of their education”.

However, ‘independent careers guidance’ could be interpreted simply as providing access to online resources. The temptation may be for head teachers and principals to scale back careers activity to the statutory minimum, though this would undoubtedly be detrimental to young people, and go against advice in a range of reports, which advocate the importance of providing a professional careers service to help young people make effective choices. The Government argues that through its proposed introduction of progression measures, reporting on the proportion of pupils achieving positive outcomes once leaving school will ensure schools continue to focus on employability skills and transition planning. Individual schools or school clusters will decide for themselves whether they take forward the kind of innovative, enterprising and engaging activities that emerged from the Timeline project.

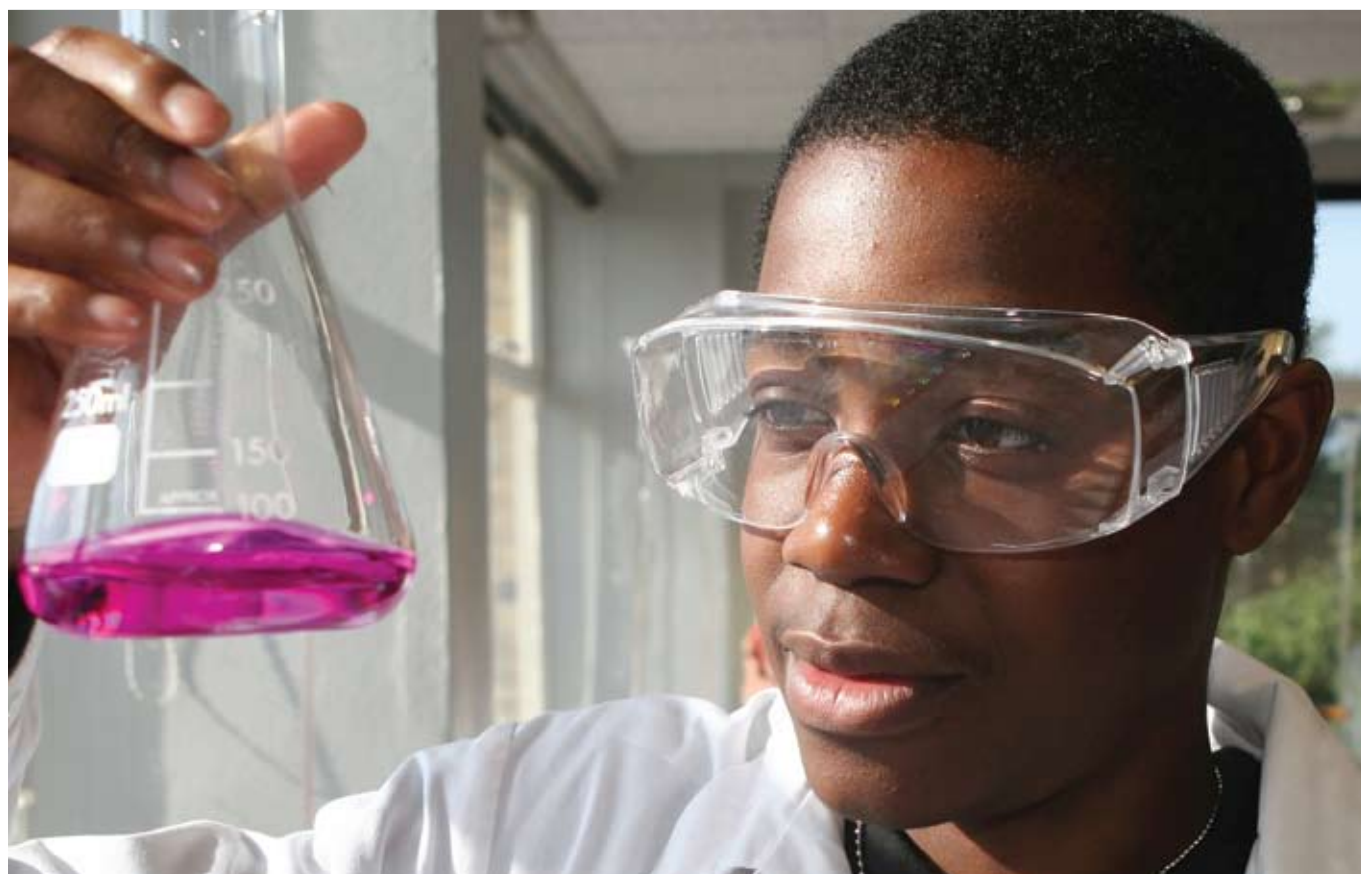
### What does STEM mean to schools?

In secondary schools, STEM is often taken as a proxy for ‘science’. There are good reasons for this. Engineering is a major driver of the STEM agenda outside of schools, but it is often not recognised by pupils or teachers, and does not form a clearly identifiable part of the curriculum. Likewise technology is identified with the design and technology curriculum, and its diverse nature makes links with the STEM agenda difficult both for pupils and teachers to visualise. Moreover, although both science and mathematics are powerful and influential subjects within schools, mathematics departments in several of the pilot schools tended to isolate themselves.

### Subject delivery and STEM careers awareness

Better careers learning within STEM subjects arises where teachers see preparation of young people for the world of work as an integral part of their job. Ideally, STEM subjects should be taught by individual subject specialists, since specialist teachers’ expertise and enthusiasm have been shown to be essential in inspiring pupils.

Links between what young people learn in STEM subject lessons and the implications for career choice must be made explicit, since there is an incorrect assumption that pupils forge links between curricular subject knowledge and the jobs available to them. Pupils also need to know that for some STEM careers, studying three separate subjects as triple science is desirable, and in some cases essential.



### The role of careers professionals

Careers staff seemed better able to make a positive contribution when they felt they had an appropriately high status role that enabled them to support the development of careers within all subject areas.

There was a shared sense that careers guidance should be independent, though this should not result in students having restricted access to information in a misplaced interpretation of impartiality. However, confusion is widespread, when it comes to differentiating between careers education on one hand and careers information, advice and guidance, on the other. Where independent careers guidance has been commissioned by schools, mechanisms should be put in place to ensure impartiality, so that young people are not channelled towards specific institutions and that their future long-term interests feature at the core of the experience.

Many young people have preconceptions of STEM careers as difficult or dull, and it is right that schools challenge these views. Often it is the attitudes of parents that lead to these entrenched and stereotypic beliefs. Schools that develop and implement approaches to engaging parents in the STEM agenda are more likely to achieve success with their learners. Industry placements for teachers, the development of long-term relationships with local employers and skilled mediation of high quality labour market information can each contribute to promoting careers from STEM subjects without undermining impartiality.

Careers progression data could also be used by schools to present a local dimension to national and regional labour market information, as well as highlighting many different routes to successful careers.

### The impact of policy initiatives

At the time of writing, there is uncertainty about the detail of revisions to the national curriculum. Ministers have, however, referred to a shift towards a more 'knowledge-based' curriculum. Such a move may challenge some of the principles of STEM, where the development of skills is a key feature, with STEM subjects brought to life by drawing on the real-world contexts of the subjects combined. This especially applies to science and mathematics, disciplines that are often seen by students as highly theoretical and remote from everyday life. Equally, STEM's aspiration to contribute to meeting the economy's need for more skilled technicians may be thwarted by an emphasis on a factually rich academic learning focus.

Some concerns have been expressed that the further devolving of school budgets will have implications for the future of work experience at Key Stage 4, which would reduce opportunities for pupils to experience STEM in a work environment.

The plan to introduce teaching schools along the lines of teaching hospitals, could contribute to the development of careers expertise in schools, through establishing centres specialising in careers education.

### What further needs to be investigated surrounding schools, STEM careers and choice?

Having coached schools through the pilot programme, mentors were able to identify some of the obstacles to implementing STEM careers awareness, and ways in which they can be overcome, some of which have been incorporated into the STEM planning tools. Mentors were also asked where future research could be targeted to improve connections between STEM subjects in schools and careers.

First, where does STEM fit with schools' strategic priorities? Second, though it is taken as read that there are obvious links between STEM subjects, what is the difference between the real and perceived connections? A further suggestion for investigation is to explore the relationship between the subject background of senior leaders and the status of STEM in schools and colleges: has there been a shift towards people with arts and business backgrounds taking up senior posts?

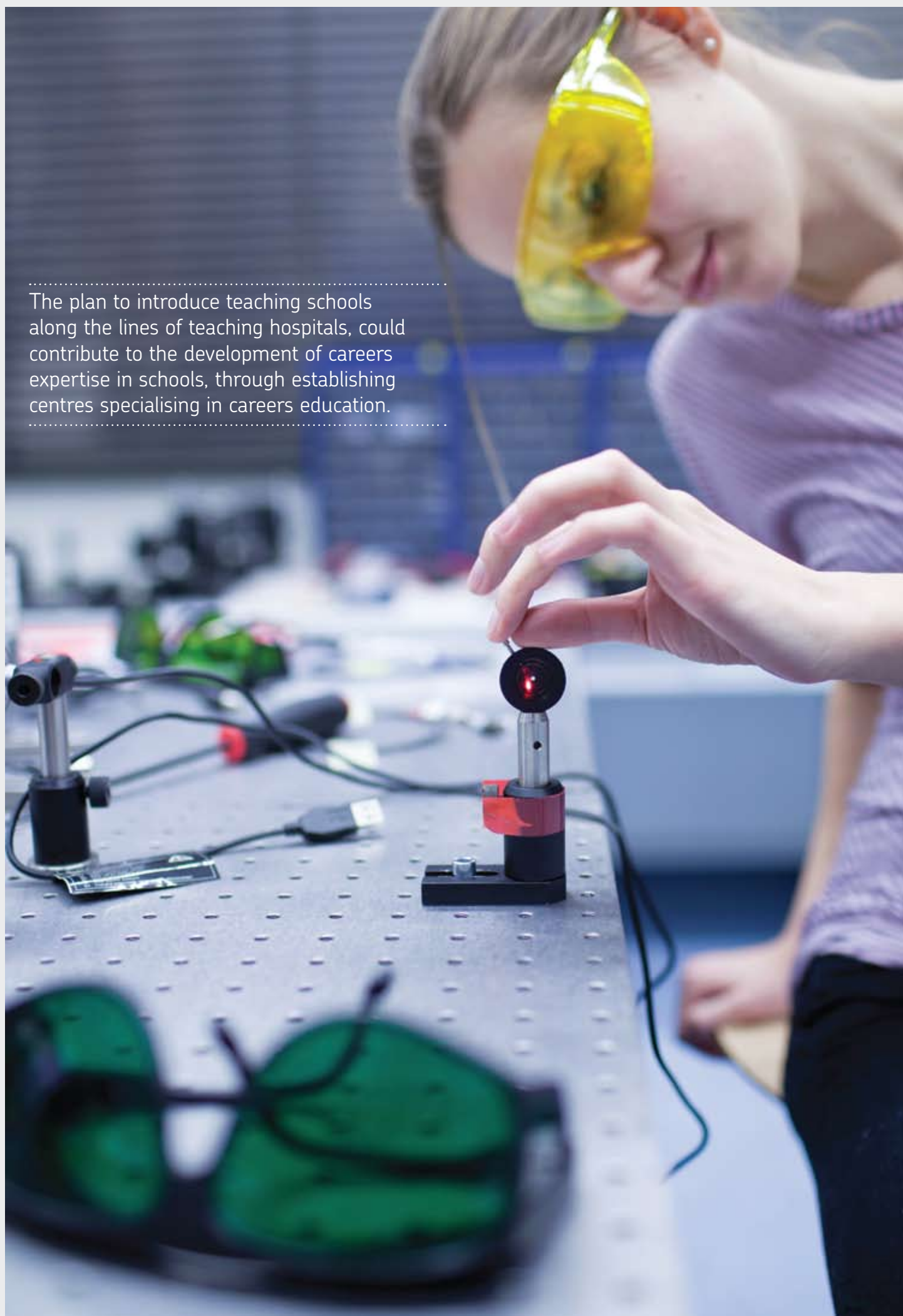
Mentors suggested that we need to know more about the knowledge base of STEM teachers, the effect this has on curriculum design and development, and the implications for subject-related continuing professional development. Some raised concerns that more experienced teachers were less likely to keep abreast of the career-related developments in their fields.

The Timeline project also raised questions about the nature of the relationship between STEM core curriculum and the enhanced, enriched curriculum. Since no other school subjects seem to draw on this type of 'top-up' to anything like the same extent, what does this say about the core STEM curriculum and the ability of STEM teachers to inspire learning in their subject?





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# Pupils' knowledge and attitudes

## How can young people decide to become engineers if they don't know what engineering is?

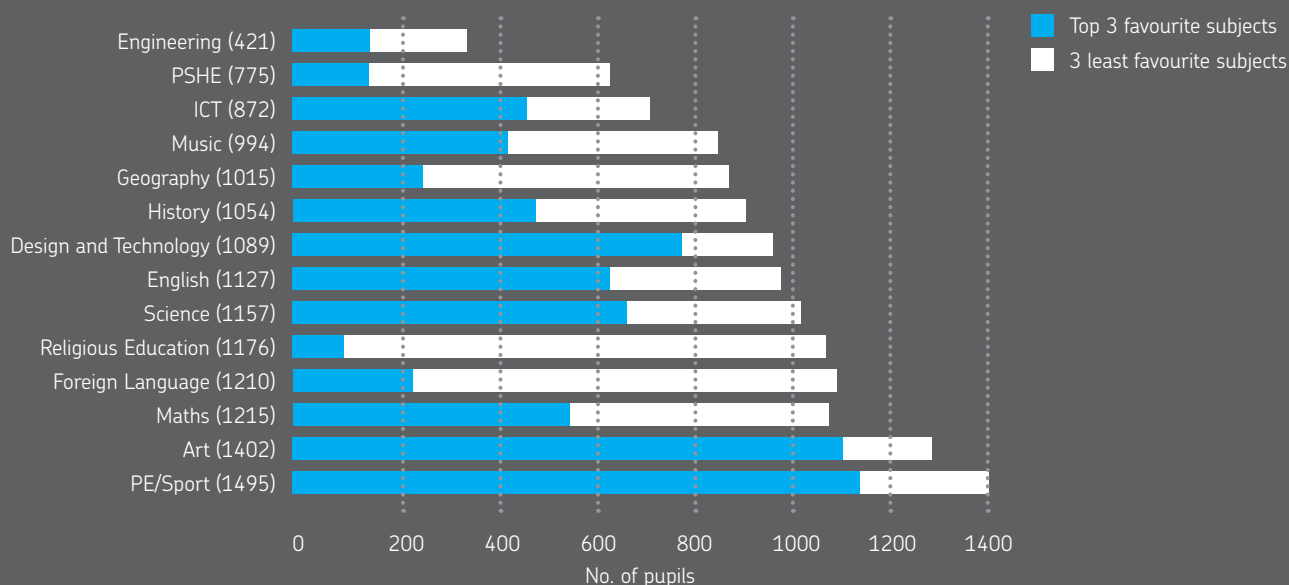
What takes place in schools forms only a part of how young people gain an understanding of what is meant by science, technology, engineering and mathematics, and how these disciplines overlap in the wider world of research, innovation and employment. It was on this basis that the project team set out to characterise pupils' perceptions of, and attitudes to, STEM subjects, to help inform its programme of work.

The research was carried out by the International Centre for Guidance Studies (iCeGS) at the University of Derby, in two waves starting in September 2008 and September 2010. Some 4073 completed questionnaires from pupils at 27 pilot schools were submitted in the first phase, with 2216 received from 19 schools in the second.

Surveys were carried out in pilot schools at these two stages, with year 7 and year 9 pupils – representing the entry and exit points for Key Stage 3. The focus of this work was to capture pupils' opinions of STEM subjects and thoughts about careers, and to gauge whether the programme of teacher mentoring had trickled down into the experience and attitudes of pupils.

Pupils were invited to rate their levels of interest in STEM subjects in comparison to other school subjects. They were also questioned on participation in activities that complemented lessons in these subjects. These surveys sought to uncover levels of awareness of the range of STEM career paths and qualifications, and sources of information that young people draw upon to inform careers decision-making more generally, and STEM careers more specifically.

Fig 1: Preference for subject at Key Stage 3, 2010,  
Total number of responses for each subject shown in brackets



### How popular and valued are STEM subjects?

The decline in pupils' enthusiasm for science and other STEM subjects is thought to be most pronounced during the period from embarking on secondary education and for the duration of Key Stage 3 (Fig 1). Factors that have been shown to affect interest, attainment and likely future uptake of STEM study include subject popularity, level of difficulty and perceived utility of the subjects. The Timeline research sought to capture attitudes to STEM subjects at either end of the key stage and to establish whether there had been changes in attitude over the duration of the project, possibly because of the interventions.

Science was ranked as the fourth most popular school subject among Key Stage 3 pupils, behind PE, art, and design and technology, which consistently remained the most popular subjects at this level. Girls were as likely as boys to choose either mathematics or science as their favourite subject. Although there was no evidence that the popularity of science decreased between years 7 and 9, relative to other subjects, there was a decline in numbers considering all STEM subjects as easy and popular, both between years 7 and 9 in the first wave, and between the first and second waves. The most significant change between the two waves was in the 'enjoyment' of mathematics, which fell by 12 percent.

Since engineering is seldom taught as a subject or identified as a specific discipline, it was either not cited as popular or rated as one of the least popular subjects. Engineering and technology were also perceived to be less important to pupils as they progress through Key Stage 3, whilst the value ascribed to science and mathematics increased. Though the level of ease that a subject presents may have some influence over its popularity, it is not possible to infer a simple correlation between levels of enjoyment and how easy pupils rate a subject. For example, while design and technology was rated as an easy and enjoyable subject, science was popular, despite being perceived as easy by only half of pupils.

### What STEM activity is taking place in schools?

Though the National STEM Programme addressed all possible aspects of schools' offering in STEM, some of the most powerful experiences were likely to be felt in extracurricular provision and through informal modes of learning. For this reason, pupils were questioned about their exposure to enrichment and enhancement opportunities.

Overall, the picture was encouraging, though not uniform across STEM subjects, with the take-up of enrichment and enhancement, such as clubs, trips and talks, generally increasing between years 7 and 9. Science seems to lead the way, with 45 percent of year 9 pupils reporting having experienced a science-related school trip and 19 percent participating in a science club. Maths clubs were attended by 13 percent of Key Stage 3 pupils, though visits based around mathematics, technology and engineering were relatively uncommon.

Role models are important in conveying the reality of pursuing a set of qualifications and career choices. Various local and informal arrangements exist, alongside the STEM Ambassadors scheme, in which volunteers with diverse STEM backgrounds come into schools, to speak to and engage with young people. Some 37 percent of pupils were able to recall presentations from external visitors about their work.

Of the sample of pilot school pupils, non-white British pupils were more likely to participate in STEM enrichment and enhancement activities than white British pupils.



### What do pupils know about STEM qualifications and careers, and where do they go to find out more?

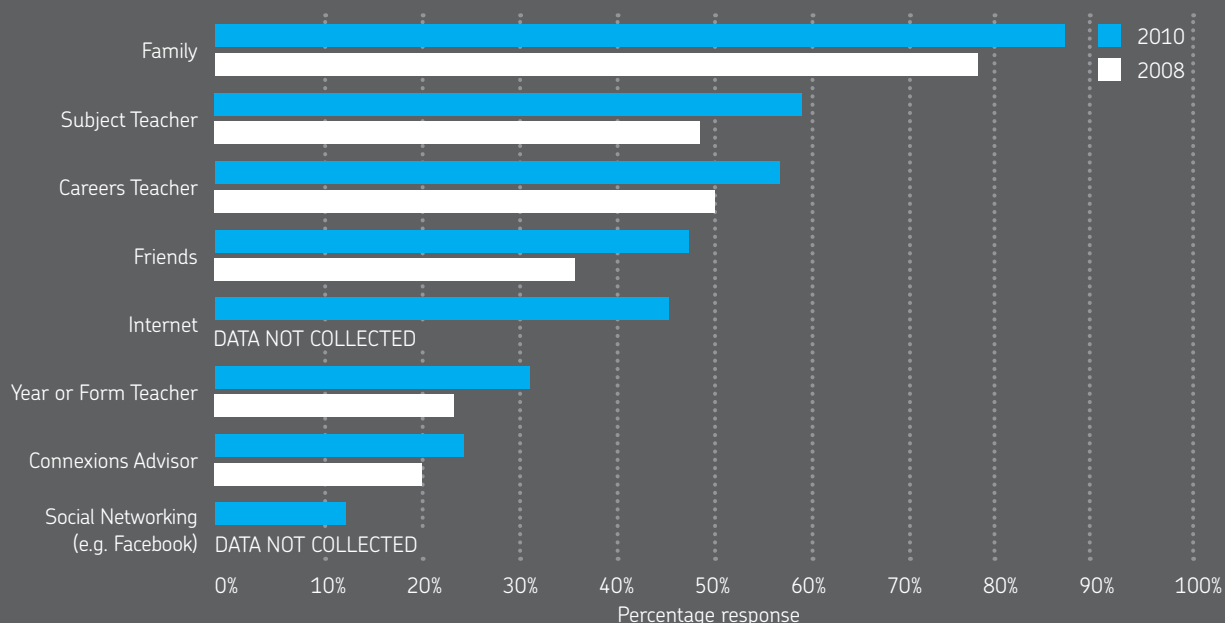
The majority of pupils were aware of the existence of diplomas, apprenticeships and A-levels as different routes into work, though fewer than one-third knew about vocational qualifications, with girls having a lower level of awareness about apprenticeships or vocational options. Most pupils were considering A-levels as their ultimate aim in school.

At Key Stage 3, pupils were most likely to seek information about jobs and careers by asking family members (Fig 2). In 2008, 48 percent of year 7 pupils stated they would ask their subject teacher for information, rising significantly to 59 percent, two years on as they moved through to year 9. Subject teachers are potentially therefore the most popular source of careers information within schools. Over 50 percent of year 9 pupils considered the internet to be a good source of information about jobs and careers, though for this age group, social networking was not thought to be a good way to find out about qualifications and the world of work.

The majority of pupils said that they would consider careers in science, technology or mathematics, with fewer than 50 percent expressing any interest in engineering. The proportion interested in science and mathematics related careers increased over the period of the research study, whilst those who might consider pursuing engineering and technology as career options fell across the period between the two waves – echoing ratings of the value ascribed to the subjects. Boys and pupils from non-white British groups were more interested in finding out about STEM careers.

Over the two waves there was a degree of consistency in the career areas that pupils would choose, especially when considering the most and least popular choices. The most likely to be chosen were design, arts and crafts, performing arts, leisure, sport and tourism. Interest in 'education and training' rose over the period of the research study, but some career areas associated with STEM fell during this time. The research found that career choice preferences were gender biased, and that these gender disparities often widened between years 7 and 9. Levels of interest by girls in design, arts and crafts were particularly high (more than 50 percent expressed an interest) whereas engineering had far less appeal for this group, with only 10 percent prepared to consider engineering-related careers.

Fig 2: Sources of information about jobs and careers, KS3









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# Building on existing provision and expertise

Most pilot schools had some form of STEM careers activity already taking place, though it tended not to be identified as such, and the activity was located within individual departments. Key roles for the Timeline project were to support better coordination and to establish a planned programme, which would be seen as benefiting both pupils and subject departments, and could continue without future external support.

The initial audit uncovered a number of findings that shaped much of the subsequent research, mentoring and consultation. Most schools were committed in principle to STEM careers and many participated in related activity without always recognising it as such. Some schools had set up STEM planning groups that included contributions from careers staff, and a few had appointed a STEM coordinator. Though not necessarily covering all STEM areas, most schools demonstrated widespread use of enhancement and enrichment activities. The audit also showed willingness among schools to develop relations with external partners.

Challenges met by the pilot project arose from other features of STEM that schools appeared to have in common. There was no real tradition of STEM departments working together, nor did the individual subject teachers have much contact with careers staff. The purpose of enhancement and enrichment activities was seen to generate interest in the subjects and they tended not to be valued for careers learning potential. Engineering was almost invisible in all but a few schools. STEM subject teachers had little knowledge of either careers education or STEM careers, and opportunities to discover more were limited by sparse professional development offerings in this area. Though parents have a major potential role to play, both as interested parties and a potential source of STEM careers knowledge and experience, they were seldom approached or engaged by schools, despite 'families' being shown by survey data to be the top choice when young people were seeking advice about careers.

Through a series of five regional consultation stakeholder conferences and two further expert workshops, the project team attempted to identify structures and strategies that needed to change to achieve stronger STEM careers awareness. Consultations examined how, amongst other factors, leadership, staffing, the physical environment and curricula presented obstacles to better STEM provision. Headline responses included:

- The seriousness with which STEM is seen is largely determined by the commitment shown by school leaders.
- The role of the STEM coordinator is a vital one. The status of the role should accord coordinators the right to be included in school planning and strategy development.
- Enthusiasm of staff is vital and more prolonged where they are rewarded and recognised for enrichment activity.
- Teachers' knowledge of (STEM) careers is limited, with understanding of pathways to careers, other than through academic routes, being poorer still. There is a real need for professional development to address this shortfall.
- Cross-curricular STEM work places a challenge on the physical spaces in which subject lessons normally take place. STEM departments should find better mechanisms for sharing their spaces, and schools should factor in STEM coordination when planning new build and renovations.
- The information coming into schools about careers is fragmented and inaccessible. Teachers, pupils, parents and others should be able to access relevant careers data from a single and clearly identifiable source.
- There is a need for better connection with the wider community, including local industry and parents.

As the Timeline pilot progressed, a clearer picture began to emerge of the circumstances under which robust cross-subject STEM was most likely to flourish. The project team drew on these emerging findings, experience on the ground and consultation with participating schools to construct an online tool, designed to help school managers put in place structures and policies to create an environment in which cross-disciplinary STEM could flourish. This online 'STEM Manager' is now available as a strategic planning tool for all schools and colleges to use, and is to be found in the National STEM Centre eLibrary ([www.nationalstemcentre.org.uk](http://www.nationalstemcentre.org.uk)).

# How to make STEM work in a school

## STEM Manager – An online planning tool for school leaders and managers



[www.nationalstemcentre.org.uk](http://www.nationalstemcentre.org.uk)

During the three years of the pilot project, individual school circumstances and the external environment both changed significantly, exposing some of the challenges for long-term commitment to STEM. From this, it was possible to identify structures and strategies of schools that proved to be resilient to the effects of changing circumstances. For example, committed leadership towards STEM and the presence of a STEM coordinator with a clear mandate, mitigated against individual committed STEM subject teachers moving on.

Through a series of consultation events, the project team identified six key areas of school planning, referred to as 'themes', that formed the basis of the construction of the STEM Manager – a planning tool designed to assist school leaders in strategic planning for STEM. These themes comprise:

- 1 Leadership
- 2 Staff
- 3 Curriculum
- 4 Enhancement and enrichment
- 5 Careers
- 6 The physical environment

Fig 4: The STEM Manager





The online STEM Manager is designed to structure discussion among school leaders and between STEM departments, with the recommendation that each theme is overseen by a relevant manager, drawing upon the support of other staff (e.g. the deputy head in charge of the curriculum oversees the 'curriculum' theme but would be expected to consult heads of subject). The six themes are set out in a hexagon as shown.

The online planning tool takes the user through successive layers, which, in turn, progress through strategic planning to operational delivery:

- Themes
- Objectives
- Actions
- Documents and resources

The rich seam of materials and documentation gathered through the STEM Careers Awareness Timeline pilot is supplemented by the extensive resources assembled by other activities funded by the Department for Education. School leaders can therefore draw on the library of policy documents, STEM job descriptions, cross-curricular planning documentation, broadcast TV programmes, and more, to assist their planning.

The mechanism for using the STEM Manager is presented in a storyboard on the National STEM Centre website. Some examples of the screens are shown below. School leaders using the STEM Manager click on each of the themes in turn, and are guided through further layers that assist them in developing relevant structures and systems. The first layer subdivides each theme into identifiable 'Objectives':

As an illustration, the Objectives under the theme of Leadership comprise:

- Establish a STEM ethos in the school
- Achieve dedicated leadership for STEM and careers in the school
- Establish school policy for STEM
- Establish monitoring, quality assurance and evaluation for STEM provision.

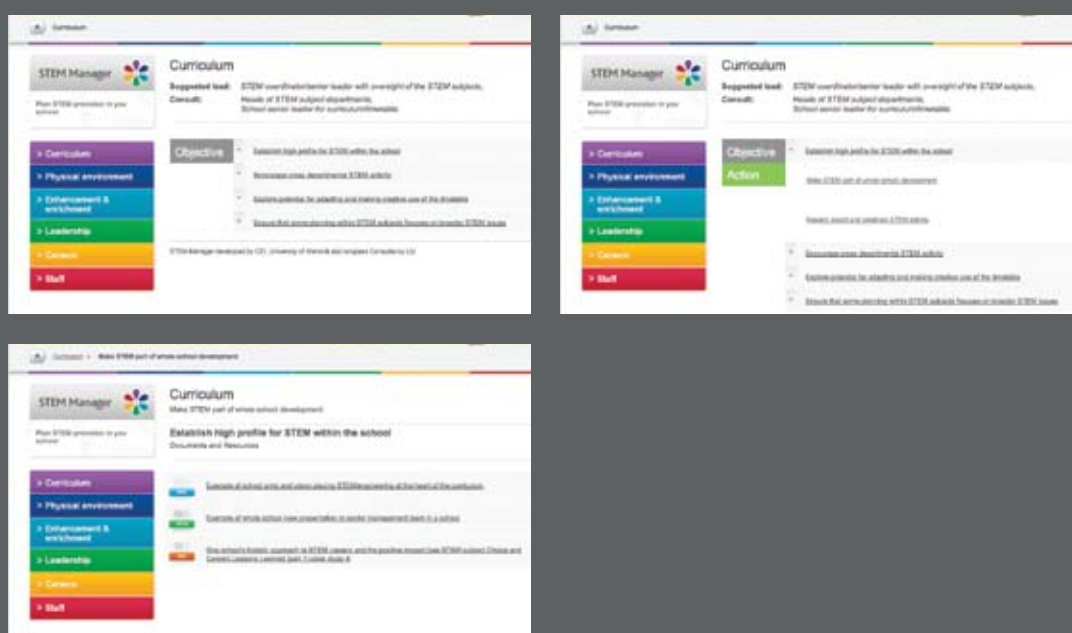
Clicking on each Objective takes the user through a series of 'Actions' that if carried out will help to meet that objective. So, for example, to establish a STEM ethos, school leaders are advised to:

- Prioritise key strategic actions
- Establish cross-curricular planning processes
- Facilitate teaching and learning styles that are active and collaborative
- Encourage linkage with other related schools activities, such as enterprise.

The power of the online tool is that it takes the user from the relative abstractions essential in strategic thinking through to the very practical realities of 'how to do it'. Many of the artefacts in the Documents and Resources layer were produced by participating schools, so they are authentic. The scores of documents, resources and links have been carefully selected to ensure that they are high quality and easy to follow. The pilot project team has also tried to ensure that they include materials from schools at different stages of STEM-readiness and under a broad range of circumstances.

In summary, the STEM Manager acts both as a primer for schools wishing to introduce or improve their STEM provision and as a reference library and archive of the work carried out by 27 schools in all parts of England, under the guidance of the Timeline project team.

Fig 5: The STEM Manager



## Planning a timeline

### STEM Planner: Incorporating STEM activity into the school curriculum



[www.nationalstemcentre.org.uk](http://www.nationalstemcentre.org.uk)

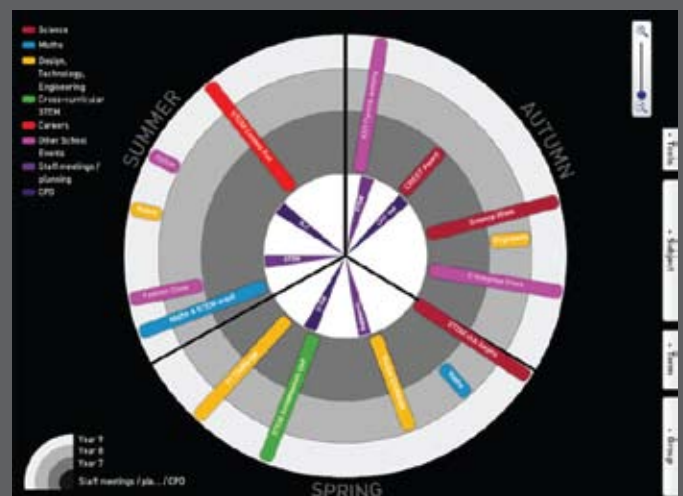
The thinking behind the Timeline pilot was to establish how schools might embed a more systematic programme of careers awareness into the existing subject curriculum, initially at Key Stage 3. This work was structured to complement the resource production and professional development focus of activity, led by the Centre for Science Education at Sheffield Hallam University, and other initiatives that took place elsewhere.

The STEM Planner is an online tool that allows STEM departments to create and then amend their programme of activity over a single key stage. The tool is flexible and so can be used in a range of contexts. It is recommended that schools create a single timeline for STEM enhancement and enrichment activity and, if they desire it, a separate curriculum timeline.

The STEM Planner helps organise STEM activity for a key stage over an entire calendar year. The planner is a sophisticated online tool that produces a colourful and high-impact schematic, though arguably its real value is in its capacity to bring together teachers from different subjects, to develop a programme of collaborative STEM activity.

The tool is based around a series of concentric circles, each representing a school year. These circles are divided into school terms. On this outline, STEM teams can plan out their proposed activity by entering prompted information on any number of planned STEM events into easy-to-use data entry boxes. The tool has been designed so that a range of variables, such as subject area, year group, and at what stage of the term the event takes place, can be taken into account and displayed in the final planner diagram. The planner can easily be adapted from a three-year key stage to a two-year one. The outcome is a clock-face highlighting where STEM activity is taking place, in which subjects, and for which year groups. It also incorporates an opportunity to include teacher planning and professional development for STEM. Once completed, a school can see how and when the focus of its STEM activity is taking place, ensuring a balanced and continual programme.

Fig 6: The STEM Planner



# Conclusion

All STEM action programmes could be said to promote careers awareness, and within the Timeline project, we have seen the objectives of STEM careers activity increasingly converge with other STEM programmes. Working with schools has shown the importance of ensuring that externally generated initiatives are planted in fertile soil.

For sustained success, management support, professional coordination, strategic planning and career development opportunities are essential. Yet, we have also seen that creating the right conditions for STEM careers can be achieved with relative ease and at low cost.

This work presents a challenge when considering the role of education in preparing young people for the future. What is a school's responsibility for linking learning to what comes next? As schools have greater freedom to determine how pupils' education is structured, how can we ensure that they include adequate opportunities for young people to consider confidently, the range of options open to them?

# Appendix

## Case studies

### Bradfield School, Sheffield

Mixed 11–16 comprehensive school for pupils, serving a rural area in the west of Sheffield. Specialist engineering school with over 900 students. Lead contact and coordinator: Andy Longstaff, Assistant Head Teacher and Director of Specialism (and his predecessor, Peter Lane).

#### Summary of key features of STEM activity

- Making use of engineering specialism to develop greater collaboration between science, mathematics, and design and technology departments, focused through separate subject coordinators.
- Drawing on whole school, regional and national enterprise events, in the teaching and learning of STEM subjects and to raise awareness about STEM careers.
- Identifying an engineering specialism coordinator in each of the STEM departments.
- Generic skills developed through learning about engineering, linked with personal learning and thinking skills (PLTS) to provide benefits across the curriculum
- Aiming to bring together the three dimensions described as Bradfield e<sup>3</sup>:
  - Engineering
  - Enterprise
  - Environment

Guided by this wider vision, the school runs a range of STEM activities, including those linked to work:

- The Perfume Project: Three days off-timetable during which 180 year 9 pupils work in small teams to establish perfume businesses. Each team is responsible for design, production and marketing of a perfume. Distillation draws on science, whereas financial planning employs mathematics. Packaging brings in design and technology, whilst advertising encourages pupils in to consider persuasive use of English. The quality of the product, team working, creativity, marketing and profitability are all assessed by external business and engineering representatives.
- The Family STEM night: The STEM Careers Timeline work has shown that parents, carers and families are seldom involved in young people's STEM learning. In 2009, Bradfield School laid on its first Family STEM Night which it continues to run, including a version for parents of new pupils. The event focused on Bradfield's engineering specialism, attracting over 50 pupils and parents, whose creativity and problem-solving skills were put to the test as they competed in 12 teams over a variety of challenges. Following the success of the first Family STEM Night, the school has extended this event to involve prospective pupils and parents from feeder primary schools, thereby providing high-quality support for the school's strategy for primary-secondary transition.

#### Other STEM enhancement and enrichment activities include:

- Weekly primary transition work with all its feeder primaries and weekly Key Stage 3 STEM Club
- Termly STEM cross-curricular primary events
- Year 7 STEM Cycle Day
- Half-termly lesson observation to identify cross-curricular STEM good practice
- Indian School Link
- Local inter-school community cohesion project (Bradfield e<sup>3</sup>)
- Formula 1 in Schools and Lego robotics
- The Cadbury Project (sponsored by Cadbury and Sheffield City Council and enabling all Engineering Diploma and GCSE Applied Engineering students across north-west Sheffield to engage in real-life STEM problem solving)
- Solar Challenge
- Inter-school year 9 STEM careers event



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## Cramlington Learning Village

Cramlington Learning Village is a specialist science and vocational college in Northumberland. It is a mixed comprehensive school of 2300 students, recognised as 'outstanding' by Ofsted three times in succession. The school became an 11–18 school in September 2008, as part of a local authority reorganisation. The main contact and driving force for this work was the Head of Careers, though there was strong encouragement and "licence to try new developments" from school senior leadership.

### Summary features of STEM activity

- Some activity taking place in the individual STEM subjects, with clear commitment from heads of subject in science, mathematics, and design and technology
- Clear responsibility for coordinating STEM assigned to the Head of Careers
- Closer relationship established between Head of Careers and STEM departments with the formation of a STEM Group
- Head of Careers was invited to join the Head of Science in working on a 'Science City' project

### Key activities include:

- Challenge Wednesdays: All Key Stage 3 pupils were off-timetable and engaged with different activities every week – including some linked to STEM subjects and careers
- Design Brief Challenge: Timeline work has led to establishment of a relationship with AAF Ltd, a local air filtration engineering company, which has provided a series of STEM ambassadors, who have participated in year 9 careers fair and year 12 careers workshops. AAF ambassadors had also set up a design brief challenge competition, led by two student design and technology teachers, which involved the winning entries having their 2D designs manufactured in 3D, following a visit to AAF in May 2011.
- Business Studies: AAF has also opened its doors to one group of year 11 and two groups of year 12 business studies students, to investigate business operations at its site
- STEM Mathematics: Production of a series of STEM-based maths activities, based around topics such as algebra, linked to careers and to business scenarios and maths content in various jobs
- The Pig Project: Design and technology-inspired project involving a robot that travels along pipelines searching for faults. Working with GE Pipelines, which provided employees as ambassadors to work with pupils, demonstrating the application of STEM in robotics and control technologies.
- Science City: Newcastle Science City is an initiative that attempts to raise the international profile of the science taking place in the city. The Head of Careers was invited by the Head of Science to participate in local authority Science City meetings and became part of the team.

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## Framwellgate School Durham

Framwellgate School Durham is a mixed comprehensive specialist Science College and Sixth Form Centre with 1260 students based in Durham. It is an active contributor to STEM initiatives at local, regional and national levels. The school hosts the Science Learning Centre North East on its campus and works closely with its main partner, Durham University, on professional development, initial teacher training and outreach programmes with STEM themes.

The school has a rich STEM engagement programme and works with a wide range of partners to deliver it. Students have the opportunity to join a STEM Club, follow CREST awards, become STEM Ambassadors for the school and gain work experience in STEM industries.

### Summary features of STEM activity

- Ensured that there was a strong link between the formal and informal STEM curricula and that enrichment experiences are capitalised on in the classroom
- Provided coordinated and coherent experiences of STEM engagement throughout a student's school career by targeting enrichment and aligning programmes to satisfy individual needs
- Embedding STEM careers education in the curriculum
- The Science Directorate already had strong links with the process industry and the local Primary Care Trust to promote STEM careers but these often focused on educational visits or events. The school attempted to derive more from these experiences for pupils and make stronger links with the curriculum.
- Teachers piloted the careers information materials provided through the project and they are now an integral part of the directorate's schemes of work
- Resources like FutureMorph were routinely used across all key stages to help pupils take a closer look at STEM sector employment.

### Key activities include:

- Developing an Action Plan: A Deputy Head, and Heads of Science and Mathematics, worked together on an action plan that focused on key areas of STEM enrichment, engagement and curriculum development, including:
  - Developing enrichment and engagement pathways.
  - Promoting enterprise through science and science career pathways
  - Contributing to STEM education and school specialism networks
  - Further developing the science and mathematics curricula to meet students' needs
  - Meeting or exceeding subject specialism targets
  - Increasing community engagement and partnership participation
- Student-centred thinking: Development of STEM enrichment activities that took into account pupils' level of development
- Development of the Timeline: Having piloted the STEM Planner, the school discovered that much of the activity centred around particular year groups and at specific times of the year. In the process of piloting the STEM Planner, the team was able to produce better-structured and more balanced distribution of activity throughout the year.
- Leadership and management: The school has a long tradition of engagement with STEM through its head teacher, and has developed a culture in line with the STEM Careers Awareness work. Arising from the relationship with the Timeline, the school decided to establish a dedicated non-teaching post to coordinate STEM enrichment, enterprise, employer engagement and work experience.

## Riddlesdown Collegiate

Riddlesdown Collegiate is the largest school in the London Borough of Croydon and the seventh largest in London with 2000 11–19 year old students on roll. It is situated on the North Downs, close to woodlands and fields, in relatively affluent suburbs close to Purley, Surrey, although the socioeconomic climate across the wider area is fairly mixed. Riddlesdown has been accredited with Artsmark, Geography Mark and the Healthy School Award. A Specialist Science college since 2004, the school has a track record of innovation and improvement in STEM subjects. The Collegiate is a set of small schools, called Colleges, each with its own head teacher and staff. Underpinning all activity is the Specialist Science status, an area in which the students excel.

### Summary features of STEM activity

- STEM Careers project was instigated by a member of the senior leadership team and responsibility for initial development and liaison with the STEM Careers mentor was given to the school's careers information, advice and guidance coordinator.
- From year 2 onwards, responsibility for STEM careers transferred to the Director of Science Specialism for Aquila College, who already had a strong commitment to and involvement in STEM, indicated by STEM careers being already well embedded in many STEM programmes and activities.
- The school has further raised awareness of STEM careers, particularly in engaging more students in physics and mathematics.
- Engineering is not taught as a separate subject at Riddlesdown, but aspects are built into the curriculum for design and technology and science. Engineering also features strongly in the STEM activities run within extracurricular clubs.

### Key activities include:

- Science Week Activity: Subject teachers from across all the colleges planning together and delivering the cross-curricular programme for Key Stage 3 during the week. Lessons planned with a central scientific theme (e.g. CSI, NASA, Einstein) whilst also attempting to raise awareness of STEM careers. In 2011, the underpinning objectives also included improving PLTS. Some students designed settlements in space and researched aeronautical engineering, whilst others researched the work of Albert Einstein. A further group investigated the work of Louis Pasteur and Alfred Wegener.
- Enrichment and enhancement: Science, technology and mathematics staff collaboratively run STEM Challenges for all Key Stage 3 and year 10 students. Pupils work in small teams to build a structure to a certain specification over a period of one hour during ordinary lesson time. Winning teams progress to a final. Examples of challenges include building a marbles sorter, constructing a bridge and designing a lunar lander.
- STEM clubs: Riddlesdown ran both science and engineering clubs, with regular input from maths and design and technology teachers, with a plan to extend this approach gradually to all STEM subjects. Activities included building gliders and building robots as part of the Lego Mindstorm challenge. The school has also taken part very successfully in the Faraday Challenge which is built into the programme for the year 7 Science Club during the autumn term.
- Year 9 and 10 'teachers' and primary school links: Riddlesdown has developed links with local feeder primary schools, through hands-on activities. Groups of year 9 and 10 students, specially trained in basic teaching skills, visit three local primary schools on a weekly basis to run STEM challenges that they have devised. The school has extended this scheme by training year 5 pupils to run science clubs for younger pupils in their schools.
- Transition project: A CSI-style investigation for year 6 pupils took place for six lessons before the summer holidays – completed once pupils have started the secondary school in the autumn term.
- Engagement of external partners: Links made with Mayday Hospital, the RAF and Royal Navy, conservation and management work of wardens at Riddlesdown Common, FutureMorph, Croydon EBP, and links with CERN in Switzerland as a first step to planning a residential trip.

### Outcomes:

- Strong STEM profile, with STEM and STEM careers being prominent in whole school events across age range
- Older students taking the initiative to run events and activities for younger students in STEM
- STEM firmly embedded in the School Development Plan

## Rushey Mead School

Rushey Mead School is a larger-than-average secondary school on the outskirts of Leicester. In 2005, the school was awarded sports and science specialist college status. The proportion of students from minority ethnic backgrounds is significantly higher than average, a large majority with an Indian heritage. For many students, English is an additional language. In the academic year 2009/10, around 90 percent of students achieved five or more A\*–C grades in their final exams. Some 67 percent of all students achieved A\*–C grades in both English and maths GCSE. More than 95 percent continue with their education post-16.

### Summary features of STEM activity

- Over the duration of the STEM Timeline pilot, there were three changes in staff responsible for overseeing this work, which, though interrupting progress, also brought additional opportunities. The STEM Coordinator is a budget holder and has three hours per week of time assigned to the role.
- The final appointment involved development of a thorough job description, which meant that the school had to carry out a careful review of progress to date.
- The school has a STEM policy in place

### Key activities include:

- STEM Club: The STEM Coordinator trained as a STEM club regional champion for ASSEC (After School Science and Engineering Clubs). She has convened meetings of local secondary schools with similar interests in starting STEM clubs, with the intention of establishing a local network
- Teaching and learning: Development of a wide range of learning materials, including starter activities for science and careers quizzes – housed on a dedicated page of the school's virtual learning environment.
- Draw a scientist: This science induction activity for year 7 pupils proved revealing in that most scientists drawn were white, and only one drawing featured a woman – despite the school being co-educational and predominantly Asian
- Activity Week: STEM featured strongly in the school's annual end of year activities, including young engineers' bridge building, a visit to The Deep aquarium in Hull, physics master classes and visits to the National Space Centre and Airkik (an indoor skydiving centre)
- Links with external careers professionals and specialists: The school forged links with Connexions, the Leicester Education Business Company, colleges and training organisations, all of which provided guidance and support to students. The STEM Coordinator made good use of the support provided by these organisations, being an active member of the local STEM network and reached out as STEM champion to develop a local community of practice.

### Outcomes:

- The STEM club has begun to attract students with a range of abilities, whereas attendance was limited to lower-ability students before the project.
- The STEM club is made up of a good balance of gender and ethnicity; the student leaders of the group chose the current members from their application forms.
- There are improved links between the subjects directly involved: science, mathematics, design and technology individuals have worked very well together.
- CREST awards have been applied for, and assemblies have taken place, raising awareness around the school.
- The school will have a STEM week in 2011, which will run at the same time as Science and Engineering week. This should ensure all students have some experience of STEM.
- The school is developing links with STEM Ambassadors.
- The school has developed links with the regional STEMNET coordinator.

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